MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 2, 2016/2017

BTS3014 –TIME SERIES ANALYSIS AND FORECASTING

(All sections / Groups)

9 MARCH 2017
9.00 a.m. - 11.00 a.m.
(2 Hours)

INSTRUCTIONS TO STUDENTS

1. This Question paper consists of **THIRTEEN** pages with **TWO** sections only.
   Section A – Twenty (25) Multiple Choice Questions
   Section B – Three (3) Structured Questions

2. Attempt **ALL** questions in both **Sections A and B**. The distribution of the marks for each question is given.

3. Answer **Section A** in the MCQ answer sheet provided and **Section B** in the answer booklet provided.

4. Statistical tables and formulas are attached.

SECTION A: MULTIPLE CHOICE QUESTIONS (25 MARKS)

1. Measures of forecast accuracy based upon a quadratic error cost function, notably root mean square error (RMSE), tend to treat
   A) levels of large and small forecast errors equally.
   B) large and small forecast errors equally on the margin.
   C) large and small forecast errors unequally on the margin.
   D) every forecast error with the same penalty.

2. Because of different units of various data series, which accuracy statistic can be used across different series?
   A) MSE.
   B) RMSE.
   C) Theil's U statistic.
   D) MAE

3. Some helpful hints on judging forecast accuracy include:
   A) Do not judge model adequacy based on large one-time errors.
   B) Do not placed unwarranted faith in computer-based forecasts.
   C) Keep in mind what exactly you are trying to forecast.
   D) All of the above.

4. Which of the following forecasting methods requires use of large and extensive data sets?
   A) Naive methods.
   B) Exponential smoothing methods.
   C) Multiple regression.
   D) Delphi methods.

5. When using quarterly data to forecast domestic car sales, how can the simple naive forecasting model be amended to model seasonal behaviour of new car sales, i.e., patterns of sales that arise at the same time every year?
   A) Forecast next period's sales based on this period's sales.
   B) Forecast next period's sales based on last period's sales.
   C) Forecast next period's sales based on the average sales over the current and last three quarters.
   D) Forecast next period's sales based on sales four quarters ago.

6. Suppose two random variables X and Y are related as follows: $Y = 1/X^2$. The population Pearson correlation coefficient should be:
   A) +1.
   B) 0.
   C) -1.
   D) .5.

Continued...

7. Quarterly time-series data with a trend can be applied to models that assume stationary data by
   A) Averaging the data over time.
   B) Taking the first difference of the original series.
   C) Taking the fourth difference of the original series.
   D) Using a moving average.

8. Which of the following null hypotheses is <u>not</u> consistent with a test for data seasonality?
   A) H_0: $\rho_4 = \rho_8 = 0$ for quarterly data.
   B) H_0: $\rho_{12} = \rho_{24} = 0$ for monthly data.
   C) H_0: $\rho_1 = \rho_2 = 0$ for annual data.
   D) H_0: $\rho_7 = 0$ for weekly data.

9. The Holt's forecasting model uses:
   A) Naive methods.
   B) Moving averages.
   C) Exponential smoothing.
   D) Adaptive filtering.

10. If the time series of interest is highly random, the seasonal smoothing constant of the Winter's model should be set
    A) equal to zero.
    B) at a small positive value.
    C) at a large positive value, but less than unity.
    D) at unity.

11. The value of the Durbin Watson test statistic in a regression with 4 regressors (including the constant term) estimated on 100 observations is 3.6. What might we suggest from this?
    A) The residuals are positively autocorrelated.
    B) The residuals are negatively autocorrelated.
    C) There is no autocorrelation in the residuals.
    D) The test statistic has fallen in the intermediate region.

12. A normal distribution has coefficients of skewness and excess kurtosis which are respectively
    A) 0 and 0.
    B) 0 and 3.
    C) 3 and 0.
    D) Will vary from one normal distribution to another.

Continued...

Use the following information to answer Questions 13 to 15.

Figure 1

Audit Trail - Statistics

Accuracy Measures	Value
Mean Absolute Percentage Error (MAPE)	6.64%
R-Square	93.70%
Root Mean Square Error	30.05

Method Statistics	Value
Method Selected	Holt-Winters
Alpha	0.41
Beta	0.37
Gamma	0.03
Decomposition Type	Multiplicative

Seasonal Indices	Value
Index 1	1.04
Index 2	1.03
Index 3	0.85
Index 4	0.99

13. Consider the Audit Trail statistics for a Winters model as shown in **Figure 1** above,
    A) the Gamma value of 0.03 indicates trend is present.
    B) the Gamma value of 0.03 indicates seasonality is present.
    C) the Gamma value of 0.03 indicates no trend is present.
    D) the Gamma value of 0.03 indicates no seasonality is present.

14. In the Winters smoothing model as shown in **Figure 1** above,
    A) the Beta value of 0.37 indicates a high degree of trend is present.
    B) the Beta value of 0.37 indicates a high degree of seasonality is present.
    C) the Beta value of 0.37 indicates that the seasonality is positive.
    D) the Beta value of 0.37 indicates there is little variation from the average value of the forecasted variable.

15. In the Winters model as shown in **Figure 1** above, index 1 refers to quarter 1 in the data,
    A) thus, quarter 3 is a below average quarter.
    B) thus, quarter 3 is an above average quarter.
    C) thus, quarter 3 is an average quarter.
    D) nothing can be deduced about quarter 3.

Continued...

16. Which one of the following is NOT a symptom of near multicollinearity?
    A) The R^2 value is high.
    B) The regression results change substantively when one particular variable is deleted.
    C) Confidence intervals on parameter estimates are narrow.
    D) Individual parameter estimates are insignificant.

17. Which of the following sets of characteristics would usually best describe an autoregressive process of order 3 (i.e. an AR(3))?
    A) A slowly decaying ACF and a PACF with 3 significant spikes.
    B) A slowly decaying PACF and an ACF with 3 significant spikes.
    C) A slowly decaying ACF and PACF.
    D) An ACF and a PACF with 3 significant spikes.

18. A process, x_t, which has a constant mean and variance, and zero autocovariance for all non-zero lags is best described as
    A) A white noise process.
    B) A covariance stationary process.
    C) An autocorrelated process.
    D) A moving average process.

19. Which of the following models can be estimated using ordinary least squares?
    (i) An AR(1)
    (ii) An ARMA(2,0)
    (iii) An MA(1)
    (iv) An ARMA(1,1)

    A) (i) only.
    B) (i) and (ii) only.
    C) (i), (ii), and (iii) only.
    D) (i), (ii), (iii), and (iv).

20. A researcher mistakenly uses deseasonalised data in calculating the seasonal factors. If she found apparent seasonal behaviour, this is best attributed to
    A) the business cycle.
    B) trend.
    C) random noise.
    D) seasonality.

21. Over a long period of time, if measured correctly, cycle factors should average
    A) zero.
    B) one.
    C) two.
    D) four.

Continued...

22. What is the major problem when using time-series smoothing techniques to forecast the cyclical component of a time series?
    A) It takes too much data.
    B) It takes too much computer time and effort.
    C) Trend reversals cannot be forecasted.
    D) Holt's smoothing estimates a linear trend.

23. Which of the following is NOT a way to generate stationarity data out of non-stationary data?
    A) First-difference the original series.
    B) Second-difference the original series.
    C) Transform the original series using logarithms.
    D) Examine a non-linear form of the model.

24. The partial-autocorrelation function correlogram should show spikes close to ____ lags if an ARMA (2, 3) -type model generates the true data.
    A) One.
    B) Two.
    C) Three.
    D) Four.

25. Besides using sophisticated ARIMA-type models capable of internally handling data seasonality, an alternative is to use
    A) seasonal dummy variables.
    B) trend dummy variables.
    C) deseasonalised data, and then reseasonalise to generate forecasts.
    D) Holt's smoothing.

Continued...

SECTION B: STRUCTURED QUESTIONS (75 MARKS)

QUESTION 1

(a) How do forecast practitioners rank various forecasting models applied to any given problem? Explain in-sample and out-of-sample forecast model evaluation. (5 marks)

(b) The time-series decomposition model, it is argued, has the advantage in allowing analysts to forecast the cyclical components of a time series. Present a brief overview of time-series decomposition paying specific attention to how the business cycle is modelled. (6 marks)

(c) Why is it of general importance to test for non-stationarity in time series data before attempting to build an empirical model? (8 marks)

(d) Is it appropriate to apply ARMA(p, q) models to data with strong trend and pronounced seasonality? Explain how you would apply the Box-Jenkins methodology to such a time series. (6 marks)

(Total: 25 marks)

QUESTION 2

(a) **Table 1.1** shows the inventory pattern and sales volume in the ABC Corporation over 11 years:

Table 1.1 Data

Year	Inventory	Sales volume
2006	2	5
2007	3	6
2008	5	6
2009	4	5
2010	3	5
2011	5	7
2012	7	6
2013	6	6
2014	7	7
2015	8	7
2016		8

(i) Find the forecast values of the inventory from 2006 to 2015 by using single exponential smoothing (SES) with a smoothing constant of 0.3 and an initial value of 2. (2 marks)

Continued...

(ii) By regressing Inventory (Y) on Sales volume, you obtain the following regression result:
$\widehat{Inventory}_t = -6.0000 + 1.8333 * Sales\ Volume$
Find the forecast values of the inventory from 2006 to 2015 by using the regression result obtained. (3 marks)

(iii) Evaluate these forecasting methods (from part (i) to (ii)) using Mean Square Error (MSE) and Mean Absolute Percentage Error (MAPE). (8 marks)

(iv) Forecast the inventory for year 2016 using the best technique based on your evaluation on part (iii). (2 marks)

(b) A parking zone located in a major shopping centre near the KL city has the following history of customers over the last four years (data are in hundreds of customers):

Period	Y	MA4	CMA	Seasonal Factors	S	T	Yhat
2012Q1	5.4					4.7	
2012Q2	7					5.0	
2012Q3	3	4.4	4.49	0.6685		5.2	
2012Q4	2	4.6	4.88	0.4103		5.5	
2013Q1	6.5	5.1	5.38	1.2093		5.7	
2013Q2	9	5.6	5.75	1.5652		6.0	
2013Q3	5	5.9	6.10	0.8197		6.2	
2013Q4	3	6.3	6.58	0.4563		6.5	
2014Q1	8.3	6.8	6.95	1.1942		6.7	
2014Q2	11	7.1	7.20	1.5278		6.9	
2014Q3	6	7.3	7.54	0.7960		7.2	
2014Q4	4	7.8	8.00	0.5000		7.4	
2015Q1	10	8.3	8.38	1.1940		7.7	
2015Q2	13	8.5	8.63	1.5072		7.9	
2015Q3	7	8.8				8.2	
2015Q4	5					8.4	
2016Q1							
2016Q2							
2016Q3							
2016Q4							

(i) Determine the seasonal index (S) for each quarter. (4 marks)

Continued...

(ii) Using the multiplicative model, make a forecast for each quarter of year 2016 (Yhat) [Hint: The fitted trend line is 4.49 + 0.2453*Time, while the cyclical index and irregular component are both set to the value of 1.0].

(4 marks)

(iii) The actual numbers of customers served per quarter in year 2016 were 11, 13, 8, and 6 for quarters 1 through 4, respectively (numbers are in hundreds). Calculate the Root Mean Square Error (RMSE) for year 2016. (2 marks)

(Total: 25 marks)

QUESTION 3

(a) What five assumptions are usually made about the unobservable error terms in the classical linear regression model (CLRM)? Briefly explain the meaning of each. Why are these assumptions made? (10 marks)

(b) Jenny, supervisor of BAC discount chain, would like to forecast the time (Time) it takes to check out a customer. She decides to use the following independent variables: number of purchased items (Items) and the total amount of the purchase (Amount). She collects data for a sample of 18 customers, shown in **Table 3.1**. She has performed several regressions as shown in **Output 3.1 – 3.4**.

Table 3.1 Data

Customer	Time	Amount	Items	Customer	Time	Amount	Items
1	3	36	9	10	6.2	55	11
2	1.3	13	5	11	0.7	13	3
3	0.5	3	2	12	1.4	21	8
4	7.4	81	14	13	9.1	121	21
5	5.9	78	13	14	0.9	10	6
6	8.4	103	16	15	5.4	60	13
7	5	64	12	16	3.3	32	11
8	8.1	67	11	17	4.5	51	15
9	1.9	25	7	18	2.4	28	10

Continued...

Output 3.1 Correlation Matrix

	Time	Amount
Amount	0.959	
Items	0.876	0.923

Output 3.2 Estimation Result (Time=f(Amount, Items))

Dependent Variable: TIME
Method: Least Squares
Sample: 1 18
Included observations: 18

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.421662	0.586385	0.719088	0.4831
AMOUNT	0.087147	0.016111	5.409153	0.0001
ITEMS	-0.038628	0.113111	-0.341502	0.7375

R-squared	0.921225	Mean dependent var	4.188889
Adjusted R-squared	0.910722	S.D. dependent var	2.869902
S.E. of regression	0.857511	Akaike info criterion	2.681446
Sum squared resid	11.02987	Schwarz criterion	2.829841
Log likelihood	-21.13301	Hannan-Quinn criter.	2.701908
F-statistic	87.70811	Durbin-Watson stat	2.430502
Prob(F-statistic)	0.000000		

Output 3.3 Estimation Result (Time=f(Amount))

Dependent Variable: TIME
Method: Least Squares
Sample: 1 18
Included observations: 18

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.263282	0.348785	0.754855	0.4613
AMOUNT	0.082068	0.006025	13.62144	0.0000

R-squared	0.920613	Mean dependent var	4.188889
Adjusted R-squared	0.915651	S.D. dependent var	2.869902
S.E. of regression	0.833503	Akaike info criterion	2.578080
Sum squared resid	11.11563	Schwarz criterion	2.677010
Log likelihood	-21.20272	Hannan-Quinn criter.	2.591721
F-statistic	185.5437	Durbin-Watson stat	2.417407
Prob(F-statistic)	0.000000		

Continued...

Output 3.4 Estimation Result (Time=f(Items))

Dependent Variable: TIME
Method: Least Squares
Sample: 1 18
Included observations: 18

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-1.276835	0.823652	-1.550212	0.1406
ITEMS	0.526112	0.072378	7.268918	0.0000

R-squared	0.767567	Mean dependent var	4.188889
Adjusted R-squared	0.753040	S.D. dependent var	2.869902
S.E. of regression	1.426199	Akaike info criterion	3.652342
Sum squared resid	32.54469	Schwarz criterion	3.751272
Log likelihood	-30.87108	Hannan-Quinn criter.	3.665983
F-statistic	52.83717	Durbin-Watson stat	1.488027
Prob(F-statistic)	0.000002		

(i) Determine the best regression equation. (2 marks)

(ii) Based on answer provided in part (i), what should Jenny conclude? (4 marks)

(iii) Using the full model, compute the residual for customer 18. (3 marks)

(iv) Using the full model, compute a forecast of the checkout time if a customer purchases 14 items that amount to \$70. (2 marks)

(c) Consider the ARMA(2,0) model: $\hat{x}_t = 0.63 + 0.17x_{t-1} - 0.09x_{t-2}$. You are given the following data for time until day z (i.e. t=z):

$$x_z = 0.31, x_{z-1} = 0.02, x_{z-2} = -0.16$$
$$u_z = -0021, u_{z-1} = 0.13, u_{z-2} = 0.19$$

Produce forecasts for the next 4 days (i.e. for times z+1, z+2, z+3, z+4). (4 marks)

(Total: 25 marks)

End of Page

Statistical Tables

Appendix 1: t-Table

two tails	0.2	0.1	0.05	0.02	0.01
One tail	0.1	0.05	0.025	0.01	0.005
df					
10	1.37	1.81	2.23	2.76	3.17
20	1.33	1.72	2.09	2.53	2.84
30	1.31	1.70	2.04	2.46	2.75
40	1.30	1.68	2.02	2.42	2.70
50	1.30	1.68	2.01	2.40	2.68
60	1.30	1.67	2.00	2.39	2.66
75	1.29	1.67	1.99	2.38	2.64
100	1.29	1.66	1.98	2.36	2.63
120	1.29	1.66	1.98	2.36	2.62
200	1.29	1.66	1.98	2.36	2.62

Appendix 2: Durbin Watson d Table

Critical Values for the Durbin-Watson Statistic (d)

Level of Significance $\alpha = 0.05$

n	$k = 1$		$k = 2$		$k = 3$		$k = 4$		$k = 5$	
	d_L	d_U	d_L	d_U	d_L	d_U	d_L	d_U	d_L	d_U
10	0.88	1.32	0.70	1.64	0.53	2.02	0.38	2.41	0.24	2.82
15	1.08	1.36	0.95	1.54	0.82	1.75	0.69	1.97	0.56	2.21
20	1.20	1.41	1.10	1.54	1.00	1.68	0.90	1.83	0.79	1.99
25	1.29	1.41	1.21	1.55	1.12	1.66	1.04	1.77	0.95	1.89
30	1.35	1.49	1.28	1.57	1.21	1.65	1.14	1.74	1.07	1.83
40	1.44	1.54	1.39	1.60	1.34	1.66	1.29	1.72	1.23	1.79
50	1.50	1.59	1.46	1.63	1.42	1.67	1.38	1.72	1.34	1.77
60	1.55	1.62	1.51	1.65	1.48	1.69	1.44	1.73	1.41	1.77
70	1.58	1.64	1.55	1.67	1.52	1.70	1.49	1.74	1.46	1.77
80	1.61	1.66	1.59	1.69	1.56	1.72	1.53	1.74	1.51	1.77
90	1.63	1.68	1.61	1.70	1.59	1.73	1.57	1.75	1.54	1.78
100	1.65	1.69	1.63	1.72	1.61	1.74	1.59	1.76	1.57	1.78
150	1.72	1.75	1.71	1.76	1.69	1.77	1.68	1.79	1.66	1.80
200	1.76	1.78	1.75	1.79	1.74	1.80	1.73	1.81	1.72	1.82

where n = number of observations and k = number of independent variables, excluding the intercept.

Formulas

Error, $\varepsilon_t = y_t - \hat{y}_t$

Mean Absolute Error, $MAE = \frac{1}{n}\sum_{t=1}^{n}|\varepsilon_t|$

Mean Squared Error, $MSE = \frac{1}{n}\sum_{t=1}^{n}\varepsilon_t^2$

Root Mean Squared Error, $RMSE = \sqrt{MSE}$

Mean Absolute Percentage Error,

$$MAPE = \frac{1}{n}\sum_{t=1}^{n}|PE_t| = \frac{1}{n}\sum_{t=1}^{n}\left|\left(\frac{\varepsilon_t}{y_t}\right)x100\right|$$

Mean Percentage Error,

$$MPE = \frac{1}{n}\sum_{t=1}^{n}PE_t = \frac{1}{n}\sum_{t=1}^{n}\left(\frac{\varepsilon_t}{y_t}\right)x100$$

Theil's U-statistics, $U = \sqrt{\frac{\sum_{t=1}^{n}\varepsilon_t^2}{\sum_{t=1}^{n}(y_t - y_{t-1})^2}}$

Naïve model, $\hat{Y}_{t+1} = Y_t$

Naïve trend model,

$$\hat{Y}_{t+1} = Y_t + (Y_t - Y_{t-1})$$

Naïve rate of change model,

$$\hat{Y}_{t+1} = Y_t * \frac{Y_t}{Y_{t-1}}$$

Naïve seasonal model for quarterly data,

$$\hat{Y}_{t+1} = Y_{t-3}$$

Naïve trend and seasonal model for quarterly data, $\hat{Y}_{t+1} = Y_{t-3} + \frac{(Y_t - Y_{t-4})}{4}$

Simple average model, $\hat{Y}_{t+1} = \frac{1}{t}\sum_{i=1}^{t}Y_t$

Moving average model for k time periods,

$$\hat{Y}_{t+1} = \frac{Y_t + Y_{t-1} + ... + Y_{t-k+1}}{k}$$

Double moving average,

$$M_t = \hat{Y}_{t+1} = \frac{Y_t + Y_{t-1} + ... + Y_{t-k+1}}{k}$$

$$M_t' = \frac{M_t + M_{t-1} + M_{t-2} + ... + M_{t-k+1}}{k}$$

$$a_t = M_t + (M_t - M_t') = 2M_t - M_t'$$

$$b_t = \frac{2}{k-1}(M_t - M_t')$$

$$\hat{Y}_{t+p} = a_t + b_t p$$

Simple exponential smoothing,

$$\hat{Y}_{t+1} = \alpha Y_t + (1-\alpha)\hat{Y}_t$$

Holt's linear smoothing

The exponentially smoothed series, or current level estimate,

$$L_t = \alpha Y_t + (1-\alpha)(L_{t-1} + T_{t-1})$$

The trend estimate,

$$T_t = \beta(L_t - L_{t-1}) + (1-\beta)T_{t-1}$$

Forecast p periods into the future,

$$\hat{Y}_{t+p} = L_t + pT_t$$

Winter's multiplicative smoothing

The exponentially smoothed series or level estimate,

$$L_t = \alpha \frac{y_t}{S_{t-s}} + (1-\alpha)(L_{t-1} + T_{t-1})$$

The trend estimate,

$$T_t = \beta(L_t - L_{t-1}) + (1-\beta)T_{t-1}$$

The seasonality estimate,

$$S_t = \gamma \frac{y_t}{L_t} + (1-\gamma)S_{t-s}$$

Forecast p periods into the future,

$$\hat{Y}_{t+p} = (L_t + pT_t)S_{t-s+p}$$

Time additive decomposition,

$$Y_t = S_t + T_t + C_t + I_t$$

Time series multiplicative decomposition,

$$Y_t = S_t * T_t * C_t * I_t$$

AR process: p-order autoregressive model

$$y_t = \gamma_0 + \gamma_1 y_{t-1} + \gamma_2 y_{t-2} + \ldots + \gamma_p y_{t-p} + \varepsilon_t$$

MA process: q-order moving average model

$$y_t = \mu_t + \varepsilon_t - \theta_1 \varepsilon_{t-1} - \theta_2 \varepsilon_{t-2} - \ldots - \theta_q \varepsilon_{t-q}$$

Regression model:

$$\text{t - statistic} = \frac{\hat{\beta} - \beta}{se(\hat{\beta})}$$